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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

November 6, 1970

REPLY TO
ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No.	: 3,507,436
Government or Corporate Employee	: Kinelogic Corporation 29 South Pasadena Avenue Pasadena, California
Supplementary Corporate Source (if applicable)	: Jet Propulsion Laboratory
NASA Patent Case No.	: XNP-09453

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes [x] No [ ]
Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of [handwritten mark]"

Elizabeth A. Carter

Elizabeth A. Carter
Enclosure
Copy of Patent cited above

FACILITY FORM 602

N71-19420 (ACCESSION NUMBER)	00 (THRU)
9 (PAGES)	(CODE)
(NASA CR OR TMX OR AD NUMBER)	08 (CATEGORY)

COSATI 14C

Fig. 1A

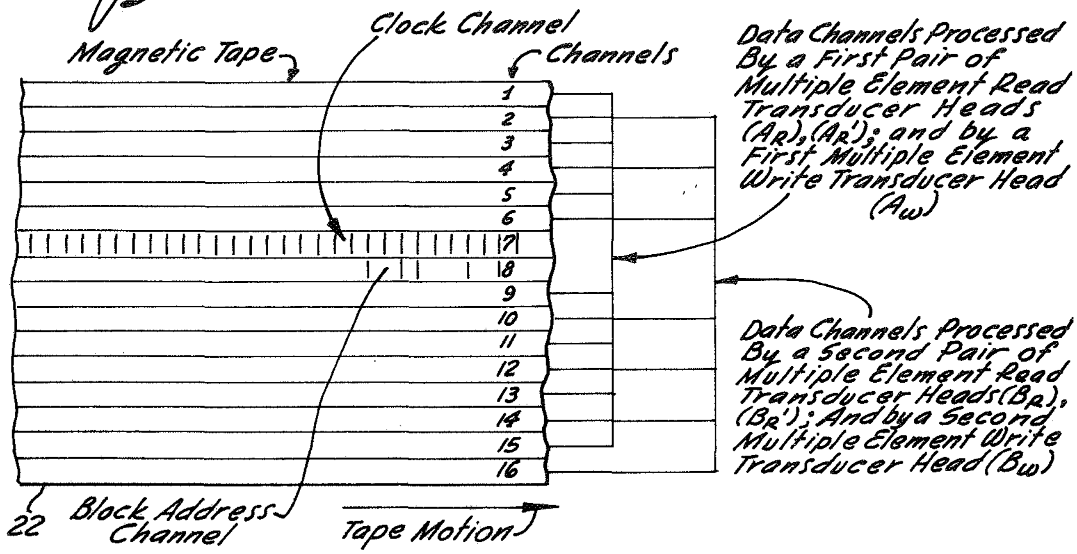
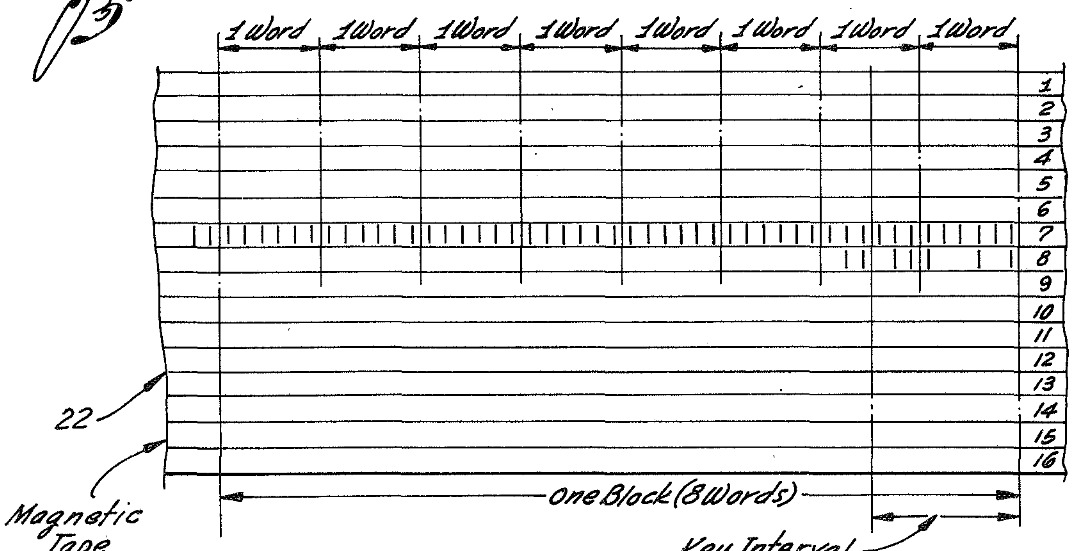


Fig. 1B



INVENTORS:
Irving Karsh
Rueben Shatazsky
By John C. Coy
J. H. Warden
ATTORNEYS

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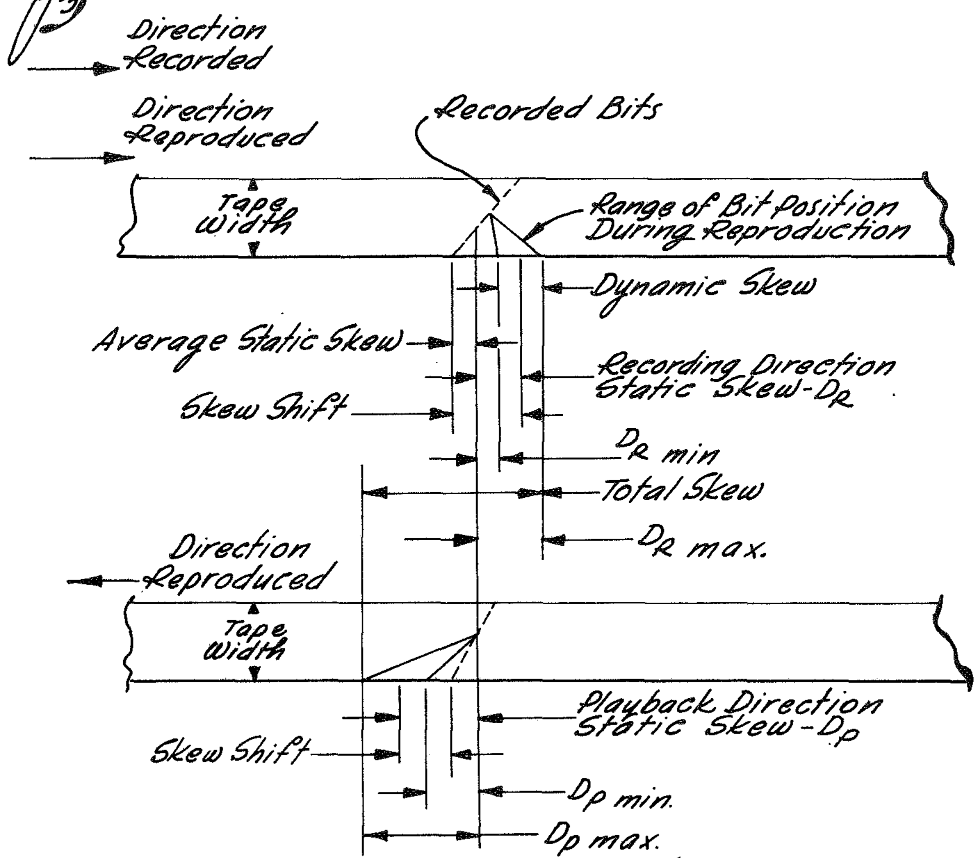
April 21, 1970 JAMES E. WEBB 3,507,436
ADMINISTRATOR OF THE NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
TAPE GUIDANCE SYSTEM AND APPARATUS FOR THE PROVISION THEREOF
Filed May 17, 1967 4 Sheets-Sheet 2

Fig. 1C



1. Total Skew $= D_R\ max. + D_P\ max.$

2. Dynamic Skew $= D_R\ max. - D_R\ min.$

3. Static Skew $= \dfrac{D_R\ max. + D_R\ min}{2} = D_R$

4. Average Static Skew $= \dfrac{D_R - D_P}{2}$

5. Skew Shift $= \dfrac{D_R + D_P}{2}$

INVENTORS:
Irving Karsh
Rueben Shatazsky
By
Geo. McCoy
J. H. Warden
ATTORNEYS

Fig. 2

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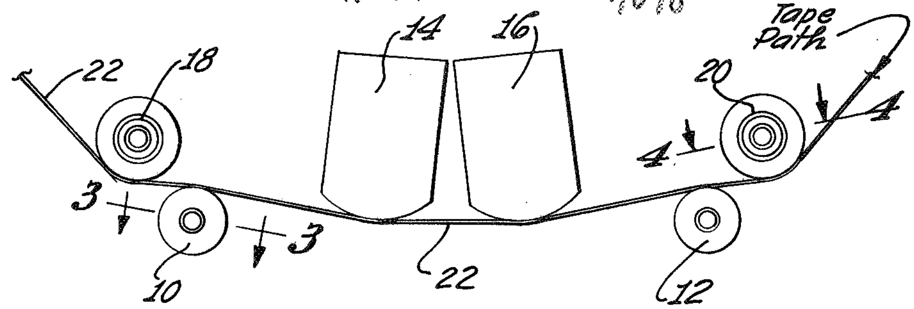


Fig. 3

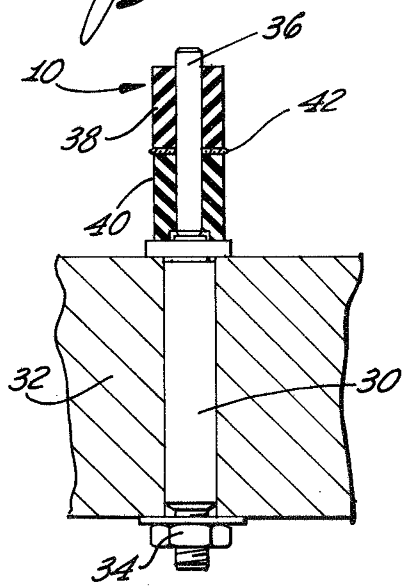
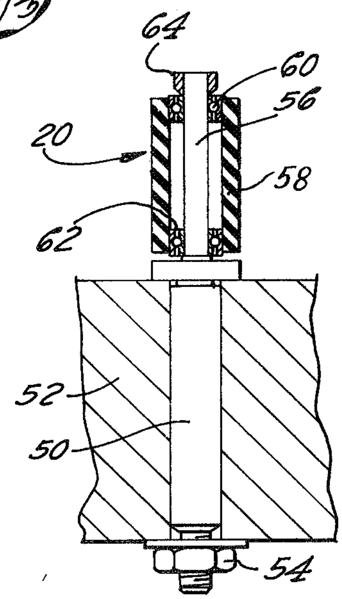


Fig. 4



INVENTORS:
Irving Karsh
Rueben Shatazsky
By
J. H. Warden
ATTORNEYS

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Fig. 5

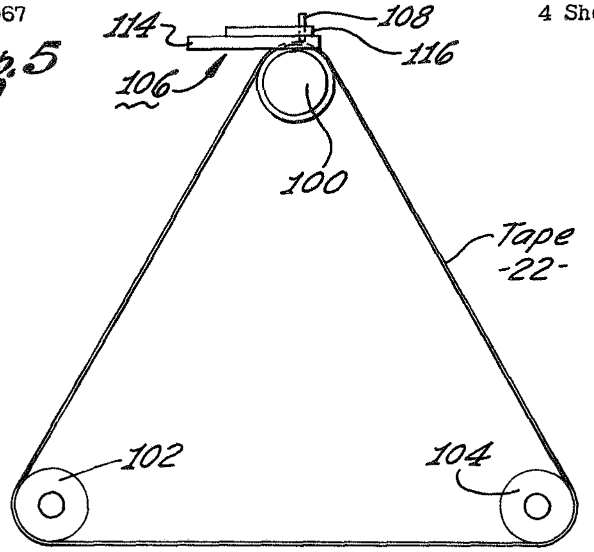


Fig. 6

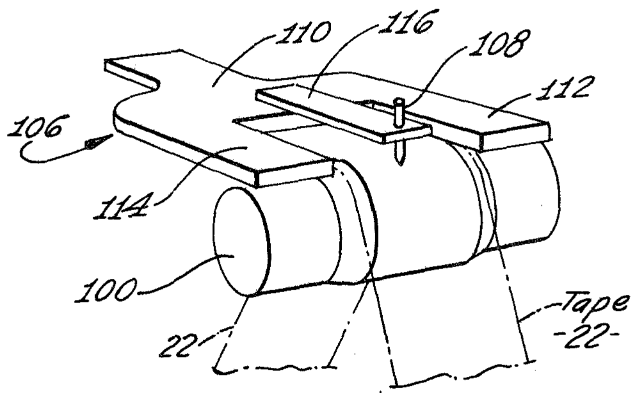
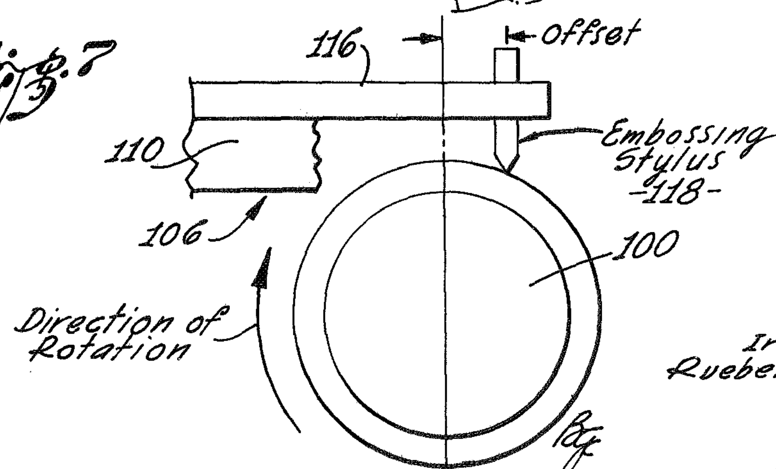


Fig. 7



INVENTORS:
Irving Karsh
Rueben Shatazsky
By
J. McCoy
J. H. Warden
ATTORNEYS

3,507,436

TAPE GUIDANCE SYSTEM AND APPARATUS FOR THE PROVISION THEREOF

James E. Webb, Administrator of the National Aeronautics and Space Administration, with respect to an invention of Irving Karsh, Los Angeles, and Rubin Shatavsky, Sherman Oaks, Calif.

Filed May 17, 1967, Ser. No. 640,448
Int. Cl. B65h *17/20, 23/04;* G11b *15/60*
U.S. Cl. 226—190 3 Claims

ABSTRACT OF THE DISCLOSURE

A tape guidance system for multichannel digital recording systems having utility for minimizing the effects of dynamic skew, and apparatus for providing therefor. The guidance system of the invention includes a groove which is provided in the tape backing. The groove in the tape backing travels on stylii located adjacent the transducer in the tape transport. The guidance groove is formed in the tape backing by apparatus which includes a stylus, mounting structure for the stylus and tape transport structure which mounts the tape and moves the tape past the stylus for forming a longitudinal groove in the tape backing. Since dynamic skew is a function of the straightness of the groove formed in the tape backing the apparatus provided for forming the groove in the tape is provided with the capability of forming a precisely formed groove so that dynamic skew thereby may be reduced to a minimum.

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; 42 USC 2457).

BACKGROUND OF THE INVENTION

The invention relates to the field of magnetic tape recording, and more particularly to the multichannel magnetic tape recording of digital information. It is conventionally known that by utilizing present day equipment and materials digital information may be recorded, and reproduced, with magnetic tapes having extremely high packing density of bits. For example, bit packing densities up to 10,000 bits per inch of the tape appear to be feasible.

The high density recording of digital bits has created problems, however, in multichannel digital recording where each multibit character is recorded as parallel bits across the tape in respective channels of the tape. This type of recording is used in most digital recording systems. However, because of the presence of what is conventionally termed dynamic skew a limit has existed for maximum possible bit density.

Dynamic skew is caused by mechanical imperfections in the tape transport and in the magnetic tape. Dynamic skew manifests itself in a transverse movement of the tape as the tape is drawn across the record/reproduce transducer. The transducer has a separate head associated with each channel on the tape, and the heads combine to sense all the bits of each successive multi-bit character as the tape is drawn across the transducer. It is apparent that dynamic skew must not exceed $\pm\frac{1}{2}$ bit if successful processing of the information is to be maintained.

Transducers are now available which make possible

the recording of 100 channels per inch of width of tape, for example, A primary goal of the present invention is to provide for the transport of such a tape, for example, across the transducer in a magnetic recording/reproducing system, with a position control for the tape which is effective to limit dynamic skew to a maximum of ± 25 micro-inches, for a one-quarter inch width of tape guided in a two-inch long guiding assembly.

Many systems, both electrical and mechanical, have been proposed in the past in an effort to overcome the effects of dynamic skew. However, these previously proposed systems, for the most part, have involved considerable system complications, such as extraneous buffer storage means, framing reference means, and the like.

SUMMARY

The present invention is predicated upon the realization that relative displacement of any channel of the magnetic tape with respect to the clock channel, which is usually located as the central channel of the tape, is primarily the result of non-linear tape movement occurring differentially across the tape. Therefore, by minimizing such differential tape movement by the proper guiding of the tape across the transducer dynamic skew can be minimized.

The system and apparatus of the present invention provides for tape guidance across the transducer by means of a longitudinal groove which is formed in the tape backing. The tape groove rides on a pair of stylii located at the leading and trailing ends of the transducer.

The groove may be formed on the tape backing by embossing techniques. The embossing may be achieved, for example, by means of a hot embossing stylus composed of a suitable material, such as included in the apparatus to be described infra. It is apparent that if intimate contact is maintained in the recording/reproducing system between the groove and the aforesaid stylii, and if the groove is accurately traced on the tape so as to be absolutely straight, transverse motion of the tape which is a function only of the straightness of the groove, and the resulting dynamic skew of the tape may thereby be minimized.

The novel features considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself as to its construction, method of operation and fabrication process, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings.

DESCRIPTION OF DRAWINGS

FIGURE 1A is a fragmentary, schematic diagram of a magnetic storage tape, illustrating the disposition of certain data, address and clock channels on the tape, and representative of a typical digital recording format;

FIGURE 1B is a diagram, like FIGURE 1A, but on an enlarged scale, the latter diagram showing more particularly the disposition of the digital data on the tape, in accordance with usual techniques;

FIGURE 1C is a diagram schematically and pictorially representing skew with respect to the magnetic tape;

FIGURE 2 represents a plan view, in somewhat schematic form, of a tape transport system utilizing a groove guidance for the tape in accordance with one embodiment of the present invention;

FIGURE 3 is a sectional view, substantially on the line 3—3 of FIGURE 2, showing the details of one of a pair of guides used in the system of FIGURE 2 so as to minimize skew of the magnetic tape;

FIGURE 4 is a sectional view, substantially on the line 4—4 of FIGURE 2, showing the details of one of a pair of rollers used in the system of FIGURE 2 in conjunction with guides such as shown in FIGURE 3;

FIGURE 5 is a somewhat schematic plan view of apparatus for forming a groove in the backing of a magnetic tape for guidance purposes;

FIGURE 6 is an end perspective view of the apparatus of FIGURE 5; and

FIGURE 7 is a fragmentary side elevational view of the apparatus of FIGURES 5 and 6.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As indicated supra, digital information recorded in many digital tape systems is recorded on tape in the form of multi-bit characters, with the bits of each character disposed in adjacent channels on the tape so that each character extends transversely across the tape. The fragmentary representations of FIGURES 1A and 1B illustrate a typical example of digital recording tape for use in such systems. As previously mentioned, digital recording tape is subject to the problems relating to skew when used as shown in FIGURES 1A and 1B.

The magnetic tape as shown in FIGURES 1A and 1B may be composed of known magnetic material exhibiting a relatively high magnetic coercive force. For example, suitable magnetic material coated on a polyester designated "Mylar" by the E. I. du Pont de Nemours Company has been used successfully as magnetic storage tape. Cellulose tapes coated with magnetic oxides have also been used successfully for the same purpose.

The tape illustrated in FIGURES 1A and 1B is provided with sixteen channels which extend lengthwise of the tape. Digital data is recorded on the tape by a series of electro-magnetic write heads respectively associated with the different channels on the tape. The digital data may be read from the tape by a corresponding series of electro-magnetic read heads which likewise are associated with the different channels on the tape.

As illustrated in FIGURE 1A, for example, a first multiple electro-magnetic transducer write element, designated A_w, may be used to record the digital data in the channels **1**, **3**, **5**, **9**, **11**, **13** and **15**. A pair of multiple element electro-magnetic transducer read heads, A_r and A_r' are provided for reading the digital data in the channels. Likewise, a second multi-element write head, designated B_w, may be provided for recording data in the channels **2**, **4**, **6**, **10**, **12**, **14** and **16**; and a corresponding pair of multi-element read heads, (B_r) (B_r'), may be used for reading the data in those channels.

The digital data is recorded in the tape in the form of multi-bit characters, as indicated supra. In the illustrated example of FIGURES 1A and 1B, each character is made up of seven binary bits and these bits are recorded simultaneously by the recording elements of the write head A_w or the write head B_w on the different channels on the tape. The resulting configuration of the data on the tape is in the form of pairs of seven bit characters, each extending transversely across the tape in the different interlaced channels.

The tape block pulses Z are recorded in the central channel No. **7** so as to minimize as much as possible the effects of the dynamic skew of the tape. The clock pulses serve to time successive pairs of the multi-bit characters. Each word on the tape in the illustrated example represents twelve characters, or six pairs, as represented by a corresponding six clock pulses in the central channel No. **7**. A block on the tape is composed of eight words. The addresses for the blocks are recorded in channel No. **8**, and these block addresses are read by individual read heads.

As mentioned above, the central channel No. **7** on the tape has clock pulses Z recorded in it. These clock pulses

are all of the same magnetic polarity, and they are recorded at fixed equidistant positions along channel No. **7** of the tape. These clock pulses, as previously explained, correspond to the position of successive pairs of multi-bit characters recorded on the tape. Each character is made up, as mentioned, of seven binary bits, and the arrangement is such that two characters are recorded in each column extending transversely across the tape as represented by a clock pulse in channel No. **7**.

An examination of FIGURES 1A and 1B will reveal that it is essential that skewing of the tape be held to a minimum in order that the various read heads may read the bits of the individual multi-bit characters without error. If the skew is greater than, for example, one-half the area required for a binary bit, bits may be lost in the reading of the corresponding characters, and errors will occur.

For a complete understanding of the invention definitions of various terms used in the specification are given. The definitions are as follows:

(a) Dynamic skew may be defined as a non-systematic displacement between two recorded bits on separate parallel channels of the tape reproduced in a given direction of tape motion. The tape motion may be either in the same direction, or in the opposite direction, with respect to the motion of the tape when the information was recorded.

(b) Static skew, on the other hand, may be defined as a systematic displacement between two recorded bits on separate channels of the tape reproduced in a given direction of tape motion. This latter tape motion, likewise, may be either in the same direction, or in the opposite direction, with respect to the motion of the tape during the recording of the digital information on the tape.

(c) Total skew, therefore, may be defined as the maximum systematic and non-systematic displacement between two recorded bits on separate channels of the tape reproduced in both forward and reverse direction of tape motion.

(d) Skew shift may be defined as the direction-sensitive component of static skew. Likewise, average static skew may be defined as the component of static skew which is constant regardless of the direction of tape motion.

The terms defined above are shown pictorially in the skew diagram of FIGURE 1C.

The tape groove guidance system of the present invention, in the embodiment to be described and as shown in FIGURE 2, includes a pair of stationary guides **10** and **12** which are positioned in the tape transport at opposite ends of the record reproduce heads **14** and **16**. The transport also includes a pair of guide rollers **18** and **20** which are disposed adjacent the respective guides **10** and **12**, but on opposite sides of the tape **22**. As illustrated in FIGURE 2, the tape **22** is drawn along the tape path across the sensitive faces of the heads **14** and **16**.

The guides **10** and **12**, as will be described in more detail subsequently, constitute stationary guides in the illustrated embodiment, and each incorporates a stylus or equivalent member which tracks a longitudinal groove in the backing material of the tape **22**. The rollers **18** and **20** serve to guide the tape with a slight wrap angle against the guides **10** and **12** so as to maintain contact between the tape and the guides.

As shown in FIGURE 3, the guide **10**, as well as guide **12**, includes a bolt **30**. The bolt is mounted in an appropriate supporting structure **32**, and is held in the supporting structure by means of a nut **34**, for example. A pin **36** extends out from the top of the bolt **30**, and a pair of axially-displaced sleeves **38** and **40** are mounted on the pin **36** in coaxial relation with the pin. A disc-like guide member **42** is supported on the pin **36** between the sleeves **38** and **40**. The guide member **42** may be composed of a suitable hard material, such as sapphire, and is provided with a beveled edge which protrudes slightly beyond the peripheral surface of the sleeves **38** and **40**.

The sleeves **38** and **40** and the sapphire disc **42**, in the illustrated embodiment, do not rotate on the pin **36**, but are held stationary. Therefore, these elements are eliminated as a source of dynamic skew motion.

The rollers **18** and **20**, as shown for roller **20** in FIGURE 4, for example, include an elongated bolt **50** which is held in a supporting structure **52** by means of a nut **54**. A pin **56** extends out from the top of the bolt **50**, and a sleeve **58** is rotatably mounted on the pin by means, for example, of ball bearings **60** and **62**. A retainer **64** holds the assembly in place.

The rollers **18** and **20** may be positioned, for example, approximately two and one-quarter inches apart in a typical tape transport and, as previously mentioned, the rollers press the tape **22** against the guides **10** and **12** with a slight wrap-around angle thereby enabling the sapphire discs, such as the disc **42**, to engage a central longitudinal groove in the backing of the tape **22**. When so assembled, the side-to-side motion of the tape as it is drawn across the sensitive faces of the heads **14** and **16** is a function only of the straightness of the longitudinal tape groove.

In a particular assembly in which the rollers **18** and **20** are disposed two and one-quater inches apart, the guide assemblies **10** and **12** may, for example, be separated by approximately two inches. When the longitudinal tape groove is made straight, within precise tolerances, the dynamic skew of the tape **22**, as it is drawn across the heads **14** and **16**, is thereby reduced to zero for all practical purposes.

Although a sapphire disc guide **42** is shown in the particular illustrated example, it is clear that other equivalent guides may be used. That is, disc guides of other appropriate material may be used, and other types of guides, such as a usual recording stylus, for example, may likewise be used in conjunction with the longitudinal groove in the tape for minimizing dynamic skew.

Presently it is considered that the disc type guides, such as the sapphire guide **42** shown in FIGURE 3, have certain advantages over the usual type of stylus in that it appears that disc type guides have a higher shock loading capacity, as well as distinct guiding advantages. The guiding advantages of the disc type guides result from their disc type shape which provides an improved lead-in for centering the longitudinal tape groove, and the longer flank length around the disc which serves to smooth out any surface roughness in the guidance groove. Additionally, small deviations from the straight line of the groove are averaged out over the relatively long contact surface of the disc type guide.

In forming the groove on the tape backing material it has been found that the formation of the groove by embossing techniques which involve the displacement of material of the tape backing from one area to another, rather than actual removal of the material, is most satisfactory. For example, the groove can be formed by embossing methods using a sapphire micro-groove cutting needle with heat applied to the needle.

The apparatus for embossing the groove on the tape, as shown schematically in FIGURES 5, 6 and 7, includes, for example, three rollers **100**, **102** and **104**. The rollers **100**, **102** and **104** may be of the crowned type. The tape **22** may be spliced into an endless loop face down around the three rollers **100**, **102** and **104**, for example, as shown in FIGURE 5, and the system may be suitably tensioned so as to provide a constant tension on the tape itself. The embossing apparatus **106** may be positioned adjacent the roller **100**.

One of the crowned rollers **100**, **102** or **104** may be a drive roller and the tape loop may be driven around the rollers a sufficient number of cycles so that it may become stabilized at a central position on the rollers. The tape embossing mechanism **106** is then brought into

position so that the longitudinal groove may be embossed on the backing of the tape.

The crowned roller **100** at the groove-forming station, for example, has a shallow hat section profile, as best shown in FIGURE 6, with the top of the hat being between one-half and two-thirds of the width of the tape **22**. The sides of the hat, for example, are made with an angle of 2°–3° and the brims are preferably made equal in diameter.

In the illustrated embodiment, the groove itself is formed, for example, by a standard phonograph sapphire stylus **108**, or equivalent tool, the stylus being heated by any appropriate means, such as by an electric heating coil, not shown in the drawings. The holder **110** for the stylus **108** is in the form of a three-tined fork, including a pair of outer tines **112** and **114**, and an inner tine **116**. The inner, or center, tine **116** is foreshortened with respect to the outer tines **112**, **114**, and, as best shown in FIGURE 6, is raised above the level of the outer tines.

The stylus **108** is mounted on the center tine with its depth adjusted so that the tip of the stylus touches the top of the hat of the roller **100** when the outer tines rest on the brims of the hat, as shown in FIGURE 6. The root thickness beneath the groove is then adjusted by offsetting the stylus **108** and holder **106** in the tangential direction, as shown in FIGURE 7. The lateral location of the groove with respect to the tape may be adjusted by axial movement of the stylus in the tine **116**. The stylus holder **106** should be offset in the direction of rotation of the roller **100**, as shown in FIGURE 7, so that the tip of the stylus drags on the material of the tape, rather than having the stylus dig into the material.

When the magnetic tape has been grooved by the apparatus shown in FIGURES 5–7, for example, it may be used in the tape transport as shown in FIGURE 2 in the manner described above, thereby facilitating increased packing density of the digital recording to be achieved without the introduction of errors due to dynamic skew of the tape.

As indicated above, various equivalents may be used in the tape guidance system and apparatus shown in FIGURES 2–4. Also, apparatus other than that shown in FIGURES 5–7 may be used in embossing or otherwise forming the groove in the tape backing material. Thus it is understood that those familiar with the art may make modifications in the arrangements as shown and described herein without departing from the true spirit of the invention.

What is claimed is:

1. A tape guidance system for a magnetic tape having a longitudinal guide groove extended along a selected surface and adapted to be drawn along a predetermined path across the sensitive face of an electro-magnetic transducer, comprising:

(A) a pair of tape-engaging guide rollers disposed adjacent to the path of the magnetic tape at opposite sides of the transducer, being so arranged relative to the face of the transducer as to cause the tape to traverse a substantially curved path between the guide rollers as it passes across the face of the transducer;

(B) a pair of stationary guide means disposed adjacent to the opposite sides of the transducer and between the guide rollers, each of said means including an arcuate peripheral surface interposed in the path of the tape in a manner such that the tape is caused to engage the arcuate peripheral surface and traverse a curved path around each of the stationary guides; and

(C) means defining an arcuate protrusion extended from the arcuate peripheral surface of each of the stationary guide means adapted to be seated within the longitudinal groove of the magnetic tape, where-by skew is substantially obviated as the tape passes across the face of the transducer.

2. The system according to claim 1 wherein the means defining the arcuate protrusion comprises a stationary sapphire disk.

3. A magnetic tape for use in a tape guidance system having a protuberant tape engaging guide comprising an elongated reelable magnetic tape member of a flexible intelligence receiving material and having a continuous longitudinal guide groove disposed in said material adapted to receive the protuberant guide to prevent skew of the tape and extended in parallelism with an edge of the tape.

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BERNARD KONICK, Primary Examiner

W. F. WHITE, Assistant Examiner

U.S. Cl. X.R.

33—18; 179—100.2; 226—196; 242—76; 274—41.4, 43; 242—76; 340—174.1